Information Science and Technology Center Seminar

Kunihiko Fukushima
Visiting Professor, Kansai University (Graduate School of Informatics,Takatsuki, Osaka, Japan)

"Use of Blur in Neural Networks for Vision"

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3:00 - 4:30 PM
TA-3, Bldg. 1690, Room 102 (CNLS Conference Room)

Abstract: Modeling neural networks is a powerful tool to uncover the mechanism of the brain, and its results are ready to use for engineering applications. We discuss artificial neural networks for vision derived from modeling approach.

One of the mechanisms that play an important role in neural networks is a blurring operation. Blurring images is usually harmful for visual information processing. If the blur is properly controlled, however, it greatly increases robustness against deformations and various kinds of noise, and largely reduces computational cost. By the word "blur", we refer both spatial blur and blur among resembling features. We look at several types of hierarchical neural networks from the standpoint of blur.

For processing images or recognizing patterns, it often become necessary to compare two images and judge if they are the same or different. In the comparison, a certain amount of deformations or noise has to be tolerated. The comparison is usually made between local features extracted from original images. A criterion for the comparison is the degree of overlapping between features. If the images are spatially blurred to a certain extent, overlap between features becomes large, and a certain amount of deformations can be absorbed. If the blur is too large, however, fine details of the images will be lost, and we fail to discriminate different features.

(a) Neocognitron: In the "neocognitron", which is an artificial neural network for visual pattern recognition, spatial blur is introduced jointly with lateral inhibition. It increases tolerance against deformation without losing the ability to discriminate different features. Blur among resembling features is produced by lowering threshold of feature-extracting cells in the neocognitron. With low threshold in feature extraction, a number of feature-extracting cells come to respond with different strengths to a single feature. It produces a situation like a population coding, which is also useful for robust comparison of local features.

(b) Interpolating vectors: Use of "interpolating vectors", which are produced by linear combinations of reference vectors in a multidimensional vector space, also increases the recognition rate in visual pattern recognition. This operation can also be interpolated as a process of blurring among resembling features.

(c) Extraction of symmetry axes: In a neural network for extracting symmetry axes of images, local features on both sides of symmetry axes are compared after multiple blurs. Namely, spatial blurs of different degrees are utilized to suppress spurious responses of the network.

(d) Completion of occluded contours: When some parts of a pattern are occluded by other objects, the visual system can often estimate the shape of occluded contours from visible parts of the contours. We proposed a neural network model capable of such function, which is called amodal completion. The model is a hierarchical multi-layered network that has bottom-up and top-down signal paths. It contains cells of area V1, which respond selectively to edges of a particular orientation, and cells of area V2, which respond selectively to a particular angle of bend. Using the responses of bend-extracting cells, the model predicts the curvature and location of the occluded contours. Missing contours are gradually extrapolated and interpolated by the top-down signals. The locations of the top-down signals have to be exactly adjusted to the locations of the bottom-up signals. The adjustment of location is accomplished by a blurring operation together with a kind of lateral inhibition.

Biography: Kunihiko Fukushima received a B.Eng. degree in electronics in 1958 and a PhD degree in electrical engineering in 1966 from Kyoto University, Japan. He was a professor at Osaka University from 1989 to 1999, at the University of Electro-Communications from 1999 to 2001, at Tokyo University of Technology from 2001 to 2006, and is a visiting professor at Kansai University since 2006. Prior to his Professorship, he was a Senior Research Scientist at the NHK Science and Technical Research Laboratories.

He is one of the pioneers in the field of neural networks and has been engaged in modeling neural networks of the brain since 1965. His special interests lie in modeling neural networks of the higher brain functions, especially the mechanism of the visual system. He invented the "Neocognitron" for deformation invariant pattern recognition, and the "Selective Attention Model", which can recognize and segment overlapping objects in the visual fields.

He received the Achievement Award and Excellent Paper Awards from IEICE, the Neural Networks Pioneer Award from IEEE, APNNA Outstanding Achievement Award, Excellent Paper Award from JNNS, and so on. He was the founding President of JNNS (the Japanese Neural Network Society) and was a founding member on the Board of Governors of INNS (the International Neural Network Society). He is a former President of APNNA (the Asia-Pacific Neural Network Assembly).

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Contact the technical host Luis Bettencourt, lmbett@lanl.gov, 667-8453; Garrett Kenyon, gkenyon@lanl.gov, 667-1900; or the institutional host Frank Alexander, fja@lanl.gov, 665-4518 for further information.

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